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The Soils of Rutherford County

University of Tennessee Agricultural Experiment Station

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Recommended Citation
University of Tennessee Agricultural Experiment Station; Mooers, C. A.; and Coryell, H. H., "The Soils of Rutherford County" (1924). *Bulletins.*
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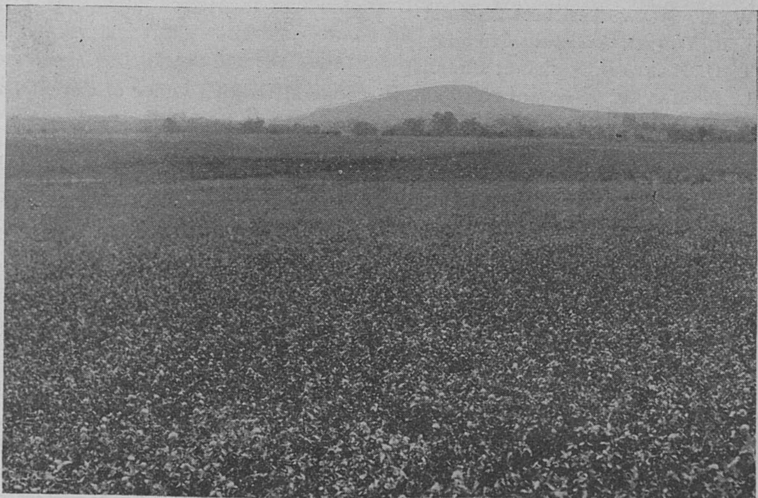
UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
Knoxville

BULLETIN No. 130. JUNE, 1924

THE SOILS OF RUTHERFORD COUNTY

BY
C. A. MOOERS
AND
H. H. CORYELL



A typical farm landscape—red clover on red land

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Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

THE SOILS OF RUTHERFORD COUNTY

By
C. A. Mooers and H. H. Coryell

PREFACE

The typical soil of most of the Central Basin is a fertile brown-colored loam underlaid by a yellowish-tinged subsoil. Rutherford County, which is located in the center of this section, is covered in large part by a red or brownish-colored soil underlaid by a red subsoil. That this type is appreciably different from those found in adjoining counties is indicated by the fact that Rutherford County leads all Middle Tennessee counties in the production of cotton. Also it is noteworthy that adjoining counties of the same latitude produce comparatively little cotton. The red land appears to be "earlier," or in some way better suited to this crop, than the other types. Because of the importance of this large body of red land it was decided to map and study it, and to include also in the study all the other soils of the county. This bulletin may be looked upon as a first report of the undertaking.

The soil survey was made in cooperation with the State Geological Survey, Dr. A. H. Purdue, State Geologist. The field work and mapping was done by Mr. H. H. Coryell, under the supervision of Dr. J. J. Galloway, Professor of Geology, Purdue University. The chemical analyses of the soils were made at the Tennessee Agricultural Experiment Station, under the supervision of the Soil Chemist, Dr. W. H. MacIntire. The field experiments were conducted through funds allotted by the State for cooperative experiments in Middle Tennessee. Credit is due to Mr. C. M. Hume and to Prof. H. P. Ogden, of the Middle Tennessee State Normal School, for the careful conduct of the field experiments.

DESCRIPTION OF THE SOILS

Round "chunks" of rock projecting above the soil illustrate the work of the agents of weathering. The surface was once all rock, the cracks and joints in which permitted the rainwater to seep down on its way to the streams. Since water has the power to dissolve and decompose the material of which the rock is made, the joints became deeper and wider, until only an occasional mass of limestone projected here and there. The joints became partially filled by the less soluble portion, the siliceous minerals, iron oxide and other matter, which the water left behind. These "chunks" that still withstand the chemical agents of erosion show the effect of weathering, having a fluted surface, sometimes quite picturesque, as if they had been channeled mechanically.

On the flat, rocky areas where the joints are closed and do not let the rainwater enter and flow into underground channels, "runoff" keeps the fine particles of soil practically all carried away, as is the case with the several acres of rock surface near Murfreesboro, known as the "Center of the State." The surface of the rock becomes warm and expands during the day, and cools and contracts at night. The water that penetrates the porous limestone freezes frequently during the winter and the ice tends to break off small particles. As the result of this expansion and contraction numerous small flakes of rock are loosened, and on many barren tracts they form an incoherent layer a few inches deep.

Processes like the above and many others of less importance tend to break up the rock into finer and finer particles. The soluble portion is carried away and the residue forms the soil—the deep, loose covering over the bedrock, the upper few inches of which is particularly adapted to supporting and nourishing plant growth. Almost no limestones are pure. On the average, a Central Basin limestone carries 8 per cent of "insoluble" inorganic impurities, which remain in large part as soil, as the lime is slowly leached out and carried away. Therefore 8 tons of earthy substance may be produced from the dissolving away of 100 tons of limestone.

SOIL COLOR

The color of soils has always been a basis for the determination of quality among farmers. The black and brown colors are considered as indications of high productivity. The dark shades are due in large part to the amount of humus matter, which is chiefly derived from decaying plant residues, but also to the amount and chemical form of oxide of iron. Extra-dark-colored lands are usually low lands and very productive. Red land is generally placed next in desirability to the brown lands. In the decomposition of the limestones which formed the majority of the soils of this county the iron impurity was changed to a red-colored oxide, which is present in sufficient amounts to give the soils their reddish color. Those of better grade are of a dark-red, or brownish color, indicating a good supply of humus and high productivity. The lighter red-tinted and gray soils are not usually looked upon with special favor. The lighter color means a scarcity of humus and is usually accompanied by a poor supply of the mineral elements of plant food. Low-lying gray soils are popularly called "crawfishy," a word which bears a distinctive meaning to all farmers who have had practical experience with such areas. It should be noted, however, that modern agricultural methods can, by proper drainage, fertilizing, and cropping, change the color of a light-tinted soil within a few years, making it become darker-colored and more productive.

SUBSOIL

Frequently there is no definite dividing line between the soil and subsoil, although the majority of the cultivated lands show a fairly distinct line of separation. The soil contains a large quantity of roots, fallen leaves, and stems, which are ultimately converted into humus. The subsoil, on the other hand, is poor in humus. There is a difference in the temperature, moisture, air supply, and presence of organisms in the soil and subsoil. The compactness of the subsoil and the small amount of humus make it less suitable to serve as a seed-bed or to be incorporated into the soil in any considerable amount at any one time. It is called "raw" in comparison with the soil, and not until exposed to the atmosphere and enriched in vegetable matter does it become properly adapted to the functions of the cultivated soil. As the surface soil is lost by erosion the subsoil must more and more be drawn upon to become surface soil. At the same time plant roots penetrate the proper subsoil, deriving from it various elements of plant food and also moisture. If the subsoil be poorly drained so that the water becomes stagnant the roots of most cultivated plants will not penetrate it and tile drainage becomes necessary. Also the subsoil may be well drained but so shallow as not to hold the moisture necessary to tide a crop over a dry spell. For various reasons, therefore, the character, condition, and depth of the subsoil are of great importance.

SOIL VENTILATION

The roots of our cultivated plants must have oxygen from the soil air to produce normal, healthy growth. The soil, therefore, must be porous and accessible to the air. Poor drainage causes insufficient ventilation. The air space becomes filled with water, which prevents the atmosphere from passing in and out. Attention to drainage is often a prime necessity in the production of a fertile soil. With good drainage the roots of many plants penetrate deep into the subsoil, and when they decay leave openings through which the air passes.

SOIL TYPES

RED LAND (Rl)*

About one-half of the area of the county is covered with a red-colored soil, which is underlaid by a red subsoil. On the accompanying map this area is colored red. When first cleared the soil was brownish-colored, but with continued cultivation, and little return of organic matter in the form of manure, sod, or green crops plowed under, the color changed slowly to red, which becomes more and more pronounced as the supply of humus decreases. It occupies a belt extending north and south across the central part, with narrow, elongated tracts, along the headwaters of the principal streams, projecting into the "glady" land. In the central area are numerous tracts, varying in size from a few acres to several square miles, of other types of soil, principally the alluvial and "glady" lands, so that the map has a mottled appearance. The red type is the principal agricultural resource of the county, and on it are properly located most of the fertility experiments that are being conducted by the Agricultural Experiment Station. Under present conditions this soil varies from brownish to various shades of red. The surface soil is from four to

*Letters in parenthesis ( ) designate map color.

eight inches deep, and contains enough clay to be easily compacted but enough coarse matter to make it a workable soil, well adapted to numerous crops. The depth of subsoil is variable. Everywhere a limestone forms the bedrock, lying from a few inches to fifteen feet below the surface. The distintegration and decomposition of certain limestones have given rise to the soil. The residue of each of the limestones—Murfreesboro, Pierce, Ridley, Lebanon, Carters, and Cannon—does not as a rule vary enough chemically to make any considerable difference in the soil produced, but by far the largest part of the red land is derived from the Ridley limestone.

The best areas of this type of soil are located south of Dilton, north of Blackman, northeast of Smyrna, and north of Lascassas. Smaller areas, equally good, could be designated in other parts of the county.

Southeast of Gum and east of Christiana is an area of approximately 28 square miles where the soil and subsoil lie upon the Lebanon limestone. The depth to the bedrock varies from a few inches to two feet. Numerous manganese pebbles, or "buckshot," lie over the surface of the soil which has not been broken or cultivated after a few showers of rain. The crops usually suffer from drought, since the soil is not sufficiently deep to retain adequate moisture. The corn grows unevenly, some stalks having a good color and making a fair growth, but many being short and slender and not producing ears. Where depressions exist, the soil is deeper and more fertile. Under good management fair yields of corn and cotton are obtained, but there is much difficulty in getting a good stand of clover. In low, moist areas along the streams where the water does not stand, bluegrass makes good pastures.

Principal Crops Grown

Corn is one of the important crops. Under usual conditions the yield varies from 10 to 40 bushels per acre, but it could be increased considerably by better methods.

Cotton has been for a long time the most important money crop in the county. Year after year it has been grown, in too many instances, on the same field, with the aid of fertilizer only, until little profit is returned. To this kind of cropping can be assigned the cause of the poor condition of much of the lands at the present time.

Clover and grass are grown to a limited extent, but thrive under favorable conditions. Cowpeas, both with and without millet, are much used for hay. Soybeans are being extensively substituted for cowpeas.

Alfalfa has only recently been introduced into the county, but thrives on any well-drained soil that has been made into a good seedbed and has been limed and inoculated.

Wheat, oats, and other small grains are grown, and, to a less extent, sorghum, crimson clover, and Sudan grass.

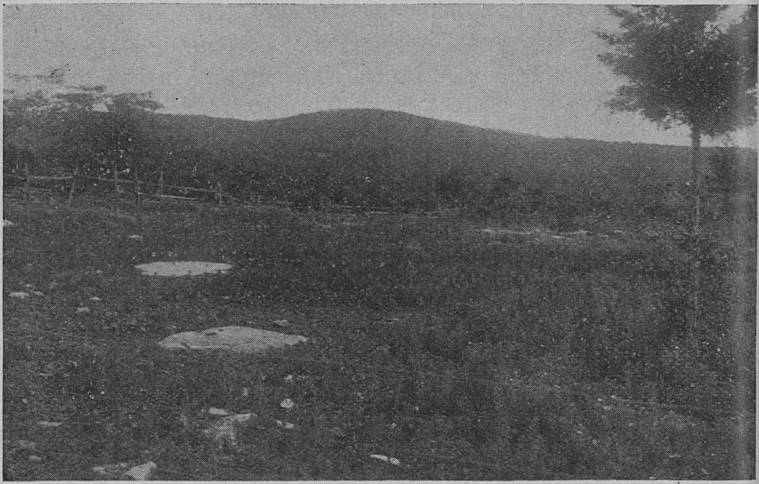
"GLADY" LAND (Lc)

"Glady" land, as the areas of shallow soil, often covered with cedar, are called, is little used for cultivated crops. In fact, there are only spots where the bedrock is entirely covered with soil; that is, more or less rock projects above the surface. This type, colored green on the map, includes all untillable lands. The Lebanon limestone underlies the major part. All the formations, however, contribute to the area. Approximately 4/9 of the county belongs to this class. Probably 1/4 of this area can be cleared of rock and become useful for crop production. The "glades" form a belt adjacent to the boundary, varying from three to ten miles in width. The area includes all of the hilly portion, but is not continuous throughout. The stream valleys and sandy soil on the hillsides are occupied by improved farms.

The soil of the Lebanon limestone is seldom deep. Thin, fine-grained slabs of rock are found scattered over the surface and mixed with the soil. The residue from the weathered Lebanon limestone is very fine and light, and the small per cent of oil makes the particles more buoyant. Lateral movement of the ground water is favored by the numerous bedding plains and the inclination of the strata. Therefore, the transportation of the decomposed rock is nearly as rapid as weathering takes place.

In the Ridley limestone area the joints form better passageways for the ground water. Solution takes place along the joints. They are widened and become filled to a considerable depth with soil so that large trees of oak, walnut, and other species find sufficient

One type of glady land



A glady section of the county

food and water there. When joints are few or closed the surface wash removes the decayed rock as fast as it is formed. The exfoliation by the sun's heat covers such surfaces with fine flakes of rock. Vegetation can not therefore grow through the entire summer season, but dies early in the spring. The young roots become dry and stiff and form a characteristic porous layer over the barren patches, which crushes easily. Before the weathering of the rock is complete, many "chunks" project above the surface. Fields of this sort are used principally for pasture.

DARK BROWN AND "BLACK" LAND (Rld)

The chrome-green color on the map indicates areas of irregular drained depressions surrounded by the red type of soil. Also it is found along the smaller streams. This soil varies in color from a dark brown to almost black. It is underlaid by a subsoil of dark gray mottled to a bluish black color. The dark color is due to the large amount of organic matter in the soil, and the constant accumulation of plant remains through many years has added fertility as well as intensified the dark color. This type of soil makes some of the best agricultural lands. When well drained it is one of the best for corn, but does not always prove to be a good wheat or oat soil, especially if there are many hard freezes during the winter. Cotton is seldom grown on the black phases, chiefly because it is too wet. Clover and timothy grow splendidly, though it is sometimes difficult to get a stand of clover. Peas, vetch, and other legumes make a luxuriant growth. The largest area of this type lies east of Eagleville. This is without doubt the largest and best general farming community of the entire county, and land values are correspondingly high.

On this type of soil, when it has received proper care, corn yields from 60 to 75 bushels per acre, while the production falls to 35 or 40 bushels on the same soil when poorly managed. Orchards do not grow well on the flat areas.

"BUCKSHOT" LAND (Rlp)

The "buckshot" land is colored brown on the map. It has been rather arbitrarily designated, since in nearly all of the flat areas are found various quantities of brownish-red manganese pebbles, or "buckshot." The areas in which the concretions formed a considerable part of the soil, or would gather in the bottom of all the gullies and small streams in sufficient quantities to form pebble beds of manganese concretions, have been mapped under this type. The productivity does not seem to be affected by the presence of the pebbles. A farm south and east of Rucker produces good crops, while the tract north and east of Gum is not so fertile. Most of the area needs draining.

The soil consists of a clay loam four to eight inches deep, underlaid with a heavy mottled clay subsoil. The subsoil shows the lack of aeration and ventilation. The soil is too wet for cotton. Corn and clover produce splendid yields on well-drained tracts.

ALLUVIAL LAND (Al)

Alluvial soil is found along the larger streams of the county. It covers about five square miles, though no area of this type is more than half a mile wide. It is colored yellow on the map.

The surface soil is a light brown, and from six to twelve inches deep. The soil and subsoil are more or less stratified, having been deposited during the high waters of the stream, though the marks of stratification are destroyed at the surface by the processes of cultivation. The subsoil is clayey, but contains appreciable amounts of fine sand and gravel. The soil is easily tilled and can be worked into a fine seed-bed. On the surface is seldom found a continuous hard crust after a rain. This type can be used for several successive corn crops and maintain fair productivity. Clover and oats make good crops to complete the rotation with corn.

The cultivation of tillage crops is at times interfered with by overflows, which carry weed seeds to the silty deposit.

The small tracts furnish some opportunity for intensive farming, though little is used in that manner at present. Some truck crops are found to do well, especially early cabbage and tomato.

"CRAWFISH" LAND (Rlb)

The soil colored blue on the map is limited to about two square miles and occupies poorly drained depressions. It contains some organic matter, but not sufficient to produce a dark color. In many places it had been leached to a pale grayish soil, commonly known as "crawfish" land.

It is quite often difficult to determine the division between the soil and the subsoil. In color they are nearly alike, the soil being a little darker gray and not so mottled, with white blotches. A stiff, compact clay layer, called "plowsole," a temporary hardpan, is sometimes found, and is probably due to the breaking of the ground when wet.

This type of soil puddles very easily, and heavy showers of rain will pack the ground so hard that it forms large, deep cracks when it dries. This type was originally covered by trees that thrive in wet soil. The land is level in most places. Open ditches and "dead furrows" provide surface drainage.

When this type is thoroughly drained it proves to be a fair corn, wheat and forage soil. Timothy will grow upon the higher portions of the area, but red top is the grass best suited to it. In areas not adequately drained the corn is at first of a dark green color, but later turns yellow, and the mature plant is small and slender, with yellow leaves.

Within the Eagleville area are many smaller areas of another type of soil not shown on the map. This soil is very dark. The subsoil is a heavy, stiff, plastic black clay when wet, but breaks up into cubical particles when dry. On the surface of this ground, especially on the upper edges of the small "clods," is seen a thin film of whitish inorganic salt. The corn becomes yellow early in its growth. The veins of the corn leaves turn yellow before the chlorophyll green of the rest of the leaf is destroyed. The plant is easily pulled up. All deep roots are dead, and only the surface roots feed the plant. Before maturing, many of the stalks are bent and crooked, and the yield is very light.

It has been found that underground drainage, with tiles only a few rods apart, has in one season made remarkable changes. The stagnant and sour underground water is removed, and every rain washes more of the inorganic salts away. This soil is said to respond to manure and fertilizer.

GRAVELLY LAND (Rg)

On the tops of the hills along the east fork of Stones River, at Jones Mill, south and east of Walter Hill, and east of Compton, are water-worn gravels. These areas are colored light purple on the map.

The area at Jones Mill is the smallest and is of no agricultural value. The others are cleared of timber and used either for pasture or tillage crops. The corn ripens early. An adequate supply of water for the growing crops is dependent almost wholly on the frequency of the rains, for the ground-water level soon sinks far below the roots of the plants and the capillary water evaporates rapidly from this coarse, pebbly soil. It would give better returns to leave these hills in pasture or woodland.

PHOSPHATIC SOILS (H)

On the sides and tops of the hills, in the hilly area that forms a nearly continuous belt about the borders of the county, are many small areas of a sandy phosphatic soil, designated by a light blue color. It is derived from the decomposition of a sandy phosphate-bearing rock which weathers to a yellowish color. The sand constituent varies in amount. This formation, known as Hermitage, weathers away faster than the limestones above or below it. The area of its outcrop on the sides of the hills is invariably "cleared" and converted into pasture lands or cultivated fields. The soil does not wash and gully readily, and steep hillsides have been cultivated for years without much destruction from surface wash. This type of soil furnishes comparatively good bluegrass pasture during a rainy season.

The nature of the soil is such that tillage crops ripen more than a week before similar crops on the heavier types. Alfalfa grows splendidly on the level portions of this soil where there is adequate supply of water. Such an area is located on the sandy soil north of Liberty Church, three and one-half miles east of Fosterville.

BARRENS LAND (P)

In the southeastern part of the county, south and east of Prater Hill, is a cherty formation (the Fort Payne chert), which gives rise, on the hilltops, to the cherty soil like that of the Barrens of the Highland Rim. These small areas, all of which do not make a single square mile of territory, are of little consequence agriculturally. Crops suffer from drought and give low yield. Corn, sorghum, and millet are the principal tillage crops. Small groves of large chestnut trees cover several acres of this kind of soil. The areas are colored purple on the accompanying map.

CHEMICAL ANALYSES OF SOILS

The chemical analysis of a soil is of value in that it is an index to the total reserve supplies of the various plant-food elements. These supplies may be extreme, either so large as to leave little doubt of their being ample, or so small as to furnish almost conclusive proof of their inadequacy. Under medium or average conditions, however, the interpretation of the analysis should be made very guardedly, especially as the analysis throws little light on the immediate availability of the elements determined. That is, both the chemical combination and mechanical condition in one soil may be decidedly different from those in another. Also a low percentage in a sandy soil may be equivalent to a high percentage in a clay soil, because the plant roots extend to greater breadth and depth in the former than in the latter. The writer considers that a chemical-soil analysis is highly valuable in connection with field experiments with lime and fertilizers. In fact, they supplement each other.

Table 2 gives the chemical analyses as made by the acid digestion method for a number of soil samples taken in various parts of the county. Table 1 gives the locality where the samples were taken and descriptive matter relating to them.

TABLE 1—*Information relating to soil samples for chemical analysis as reported in Table 2.*

Laboratory number	Locality	Soil color	Formation from which derived	Depth to underlying rock	Forest growth	REMARKS
4660	On hilltop 4½ miles N. E. of Murfreesboro.	Light brick red	Carters limestone	1½-2½ ft.	Black oak, hickory.	Old field planted to corn, 15-20 bushels yield. Found on or near top of some of the highest hills.
4663	Hall's Hill pike, Taylor's Chapel.	Brownish red. Considerable variation in field	Lebanon limestone	1-1½ ft.	Cedar, persimmon, hickory, walnut, black oak.	Old field on farm of J. W. Benson. Said to produce 15-20 bushels corn per acre. Typical Lebanon conditions.
4664	Hall's Hill pike, Taylor's Chapel.	Redder than 4663	Lebanon limestone	1-1½ ft.	Cedar, persimmon, hickory, walnut, black oak.	Subsoil to 4663.
4666	2½ miles west of Murfreesboro.	Brownish red	Murfreesboro limestone	2-4½ ft.	Black locust, cedar, hickory.	Old field. Produces 700 to 800 pounds seed cotton or 20-25 bushels corn per acre.
4667	2½ miles west of Murfreesboro.	Redder than 4666	Murfreesboro limestone	2-4½ ft.	Black locust, cedar, hickory.	Subsoil to 4666.
4668	1½ miles N. W. of Almaville.	Yellowish gray	Lower Hermitage (fine sandstone and shale)	1-4 ft.	Elm, oak, poplar, beech, locust, walnut.	Old field, inclined to be wet. On farm of T. B. Newman, Arrington. Corn following clover. Corn good in dry year. Phosphate rock in field. Soil sandy. Both sandy and clayey subsoil.
4670	Near Armstrong branch, on Franklin pike.	Red	Ridley limestone		Walnut, hickory, oak.	Old field on farm of J. C. Clark, about 5 miles west of Murfreesboro, on Franklin pike.
4672	Near Rucker.	Light brown	Ridley limestone	2½ ft.	Elm, locust, hickory.	Old field on farm of J. E. Hallyburton, Rucker. Said to produce 35-40 bushels of corn per acre. Considerable "buckshot" in soil.
4673	Near Rucker.	Light brown	Ridley limestone	2½ ft.	Elm, locust, hickory.	Subsoil to 4673
4674	3 miles N. E. of Eagleville.	Gray				"Crawfishy" soil. In spots over flat land.
4675	N. E. of Eagleville	Gray				"Crawfishy" soil. Occurs in spots in field.
4681	3½ miles west of Christiana.	Light red	Lebanon limestone	3-4 ft.		
4682	3½ miles west of Christiana.	Light red	Lebanon limestone	3-4 ft.		Subsoil to 4682
4685	1½ miles west of Almaville.	Yellow gray	Hermitage			A phosphate soil. Similar in appearance to 4668.
4687	Near Blackman.	Brownish	Ridley limestone			Old field on farm owned by R. H.

TABLE 2—*Chemical analysis of soils from Rutherford County soil survey.*

Soil No.	Insoluble matter and materials soluble in hydrochloric acid of 1.115 Sp. Gr.							Volatile matter	Nitrogen N	Reaction by thiocyanate
	Insoluble residue	Iron and aluminum oxide F_2O_3 and Al_2O_3	Manganese oxide Mn_3O_4	Lime CaO	Magnesia MgO	Potash K_2O	Phosphoric acid P_2O_5			
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	
4660	84.01	10.64	.26	.496	.372	.164	.077	6.82	.090	Acid
4663	72.49	15.64	.15	1.952	.776	1.090	.075	12.15	.169	Sl. acid
4664	70.34	20.49	.16	.848	.936	.920	.063	10.35	.085	Acid
4666	86.97	8.72	.33	.216	.296	.399	.075	8.30	.085	Acid
4667	83.56	12.07	.21	.320	.412	.392	.050	7.87	.058	Acid
4668	80.52	10.51	.09	1.600	.562	.340	1.915	6.65	.107	Str. acid
4670	76.80	8.74	.25	.400	.300	.215	.075	11.80	.089	Sl. acid
4672	86.22	7.99	.15	.307	.286	.222	.074	6.76	.143	Sl. acid
4673	84.11	10.24	.14	.480	.350	.392	.064	6.37	.095	Acid
4674	87.69	6.26	.13	.624	.381	.209	.073	8.34	.179	Sl. acid
4675	78.15	11.71	.13	.928	.555	.591	.190	10.52	.217	Str. acid
4681	81.42	12.93	.33	.400	.429	.535	.071	6.75	.097	Acid
4682	79.58	14.43	.25	.312	.483	.352	.076	6.86	.093	Acid
4685	83.55	9.44	.14	.928	.278	.190	1.552	5.57	.071	Sl. acid
4687	83.41	9.44	.22	.768	.501	.134	.145	7.91	.179	Str. acid
635*	81.92	10.53	.38	.220	.235	.294	.081	5.42	.116	....

*Per cent sulphur trioxide in soil No. 635 was 0.047.

COMMENTS ON THE ANALYSES

The Insoluble Residue

The insoluble residue is the siliceous matter left after digestion in the strong acid, which is supposed to dissolve all the lime, phosphoric acid, potash, and other mineral elements which can become available for plant use in near future years. As a rule the best soils in the State run from 75 to 85 per cent of insoluble residue—percentages which we find in Rutherford County soils. The poorest soils, on the other hand, generally show 90 per cent or more.

Iron and Aluminum Oxides

Iron is a necessary element of plant food, but only a very small amount is required. Soils like these are looked upon as high in these elements. The red and yellow colors in soils are due to oxides of iron.

Manganese Oxide

Manganese is not a necessary plant-food element, but may play some indirect part in plant growth. These soils are evidently well supplied with it.

Lime

Lime is very important to plant growth. In comparison with other soils in the State these are fairly well supplied. The fact that clover thrives may be considered as corroborative evidence. That the supplies of lime are not great is indicated by alfalfa, which has a higher lime requirement than any other crop, and as a rule requires liming. Two analyses, Nos. 4663 and 4668, show high percentages. These two soils are from the decomposition of a formation which carries deposits of phosphate. This lime is probably combined with the phosphoric acid and therefore not in a form to correct soil acidity.

Magnesia

Magnesia is an important element of plant food. It is found in the seeds of plants in much greater quantity than lime. Magnesia is an essential constituent of the green coloring matter of leaves, and a deficiency of this element gives rise to a disease of tobacco known as "sand drown," which is characterized by a whitening of the leaves between the ribs, a condition more marked in the lower than in the upper leaves. It affects the blades of corn in a similar manner, giving them a more striped appearance than is normal.

These soils appear to be above the average in magnesia content. Little attention has been given to this element until recently and there is the possibility of its being of more importance than has hitherto been realized.

Potash

Potash has long been recognized as an important element of plant food. A deficiency in the soil shows itself first of all, in wheat, for example, in a decreased growth of stem and leaf, but without a corresponding decrease in grain production. Similarly a deficiency of potash is especially detrimental to a hay crop. Also it is important in the production of potatoes. The table shows Rutherford County soils vary greatly in their supplies of this element. A percentage of 0.25 to 0.40 is rated as good, and those showing more are considered rich in potash; but the analysis is not an infallible guide, so that great stress can not be placed on the results.

Phosphoric Acid

Phosphoric acid is one of the fundamentally important elements of plant food. Plants require only one-fourth to one-half as much phosphoric acid as potash, but the soil supply of phosphoric acid is much more likely to be deficient than that of any other element. A deficiency cuts down not only stem and leaf but also grain and fruit production. Soils 4668 and 4685 are derived from the decomposition of phosphate rock and are exceptionally rich in phosphoric acid. The majority of the soils, however, have poor supplies, and it is not surprising to find that phosphatic fertilizers are in common use.

Volatile Matter

The volatile matter is that part of the soil which is lost when subjected to strong heat. All vegetable matter, also chemically combined water and carbon dioxide, are included. Fertile soils are nearly always high in volatile matter and poor soils low. This is not, however, a good guide because a poor clay, low in vegetable matter, may show a much higher content of volatile matter than a fertile loam. This is due to the large amount of combined water in the clay.

Nitrogen

Nitrogen is another of the very important plant-food elements in the soil. The most marked difference between the chemical analysis of a poor, worn soil and that of fertile new land is the content of nitrogen, the new land being far better supplied than the old land of the same kind. Nearly all the nitrogen is contained in the dark-colored vegetable matter, or humus, of the soil, and the supply in the surface soil is much greater than in the subsoil. Erosion and long-continued cropping in corn and cotton have greatly reduced the nitrogen supply of Rutherford County soils. Such crops as red clover, sweet clover, and alfalfa, also mixed clover and grass pastures, and the application of farmyard manure, are the most important means of restoring nitrogen and thereby building up soil productivity.

Reaction

The reaction of a soil—acid or alkaline—is a good indication of lime requirement. All these soils reacted more or less acid, indicating need of lime.

TABLE 3—*Fertilizer and liming experiments with soybeans—yields in tons of hay per acre.*

(Fertilizer and liming rates per acre: 300 pounds acid phosphate; 100 pounds muriate of potash; 2 tons ground limestone).

Farm of	Color of soil	Fertilizer: None, Limed	None, Unlimed	Phosphate, Limed	Phosphate, Unlimed	Potash, Limed	Potash, Unlimed	Phosphate and potash, Limed	Phosphate and potash, Unlimed	Remarks
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	
Prof. P. A. Lyon (southeastern part of county)	Brown	1.74	1.37	1.92	1.52	1.84	1.45	1.88	1.63	All crops grown in 1916
A. N. Miller (west of Rucker)	Red	1.81	1.56	2.37	1.60	1.85	1.50	2.18	1.83	
Ed Campbell (west of Murfreesboro)	Red	1.50	1.20	1.82	1.48	1.19	1.05	2.36	1.42	
State Normal Farm (in Murfreesboro)	Red	2.41	2.17	2.81	2.67	2.32	2.06	2.85	2.22	
Average		1.87	1.58	2.23	1.82	1.80	1.52	2.32	1.78	

Sulphur

Sulphur is one of the necessary plant-food elements, but was estimated in only one of the soil samples, No. 635. The per cent of sulphur trioxide, 0.047, is small, but is slightly greater than the average from nineteen soil samples from the Central Basin, as reported in Bulletin 78, "The Soils of Tennessee." Thus far in this Station's field experiments the need of addition of sulphur for plant-food purposes has not been demonstrated for any soil in the State. Apparently the natural supplies, together with that brought down in the rainfall, are ample. In this connection mention may be made of the fact that acid phosphate contains nearly 50 per cent of land plaster, or calcium sulphate, a form of sulphur readily utilized by plants.

FERTILIZER EXPERIMENTS ON RED LAND

WITH SOYBEANS

In 1916 four series of field experiments were made to determine the response of soybeans to phosphate, potash, and lime on different farms in the county. Table 3 gives the results obtained.

Results from only a single season afford an indication of soil need, but their value can be easily overrated. In fact, because of seasonal peculiarities and variation in the fertility of the different plots in any series, only general conclusions are warranted. The results of these series, however, are a unit in indicating a general soil need of both phosphate and lime, but no need of potash.

WITH MILLET

In 1910 a series of fertilizer experiments with millet for hay was conducted on the farm of Mr. A. N. Miller, near Rucker. The treatments and yields obtained are given in Table 4.

TABLE 4—*Fertilizer experiments with millet on farm of A. N. Miller, near Rucker.*

(Fertilizer rates and yields per acre)

Series	Fertilizer	Yield of hay	Remarks
		Tons	
1	None	0.90	There were five plots in each series; a total of 25 plots being harvested separately to get the data given. The crop was grown in 1910.
2	300 lbs. acid phosphate	1.42	
3	300 lbs. acid phosphate 100 lbs. muriate of potash	1.38	
4	150 lbs. acid phosphate 100 lbs. muriate of potash	1.25	
5	600 lbs. acid phosphate 100 lbs. muriate of potash	1.80	

The results show a decided response to acid phosphate, but no increase from potash.

WITH ALFALFA

Table 5 gives the results of fertilizer, lime, and manure experiments with alfalfa, carried out for three years on red land on the farm of the Middle Tennessee State Normal at Murfreesboro. Plots 1 to 5, inclusive, had been limed with ground limestone in 1916 at the rate of two tons per acre. The fertilizers mentioned were applied in the summer of 1920. Seeding was done the same season, a good stand being obtained on all plots.

The results show marked increases from phosphate, manure, and lime, but little or no certain increase from potash.

TABLE 5—*Yields of alfalfa in experiments on the farm of the Middle Tennessee State Normal, Murfreesboro—red land.*

Plot No.	Fertilizer treatments per acre	Yields of hay per acre				Notes
		1921	1922	1923*	3-year average	
		Tons	Tons	Tons	Tons	
1	Acid phosphate, 600 lbs. Muriate of potash, 100 lbs.	2.57	4.20	1.76	2.84	Ground limestone applied at the rate of two tons per acre to plots 1-5 in 1916.
2	Acid phosphate, 600 lbs.	2.74	3.74	1.62	2.70	
3	No fertilizer	1.87	2.90	1.18	1.98	
4	Manure, 12 tons	4.15	4.96	2.51	3.88	
5	Manure, 12 tons Acid phosphate, 600 lbs.	4.77	5.05	2.59	4.14	
7	Acid phosphate, 1200 lbs. Muriate of potash, 200 lbs.	1.08	.85	.80	0.91	Unlimed—chiefly crab grass

*First two cuttings.

WITH A FIVE-YEAR ROTATION

Table 6 gives the fertilizer treatments and crop yields obtained in a five-year rotation of wheat, clover and grass (two years), corn, cotton, and soybeans. The experiments were conducted on the farm of the Middle Tennessee State Normal, at Murfreesboro. The rotation was run on each of five different ranges, thus allowing the production of each crop every year. It should be explained, however, that instead of each crop occupying a whole range, as did the other crops, one half of a range was planted to corn and the other half to cotton. Each range in these experiments was divided into thirteen 1/40-acre plots, which were fertilized according to the plan shown in Table 6. Every third plot was a check, or no-fertilizer, plot, there being four such plots to a range. In the table the yields of the no-fertilizer plots were averaged and are not shown in detail.

Alfalfa a failure on unlimed land

Alfalfa a success on limed land

TABLE 6—*Fertilizer treatments and yields per acre of the several crops grown in a five-year rotation of corn-cotton, soybeans, wheat, and clover and grass (2 years) on a brownish-red soil. Experiments on the farm of the Middle Tennessee State Normal, Murfreesboro.*

Series	Fertilizer	Wheat 1920 Grain	Wheat 1920 Straw	Wheat 1921 Grain	Wheat 1921 Straw	Wheat 1922 Grain	Wheat 1922 Straw	Wheat 1923 Grain	Wheat 1923 Straw	Wheat 4-year average Grain	Wheat 4-year average Straw	Clover and grass hay 1920	Clover and grass hay 1921	Clover and grass hay 1922	Clover and grass hay 1923	Clover and grass hay 4-year average
		Bu.	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons	Tons	Tons	Tons	Tons	Tons
1	Acid phosphate 200 lbs.	8.4	0.93	20.7	1.60	17.5	0.98	16.0	1.50	15.7	1.25	0.86	1.69	2.78	2.52	1.96
2	Acid phosphate 200 lbs. Muriate of potash 25 lbs.	10.6	0.96	21.4	1.71	13.2	1.21	18.3	1.47	15.9	1.34	0.87	1.35	2.94	2.44	1.90
3	No fertilizer (average of 4 check plots)	9.4	0.82	12.8	0.91	6.3	0.80	7.8	.77	9.1	0.83	0.53	1.00	1.82	1.44	1.20
4	Nitrate of soda 100 lbs.	6.3	0.61	12.3	1.00	8.6	1.14	7.0	.73	8.6	0.87	0.67	.81	2.02	1.76	1.32
5	Acid phosphate 200 lbs. Nitrate of soda 100 lbs.	12.4	0.88	17.2	1.37	13.0	1.06	17.3	1.42	15.0	1.18	0.73	1.81	2.96	1.40	1.73
6	Muriate of potash 25 lbs. Nitrate of soda 100 lbs.	8.1	0.63	15.3	1.07	6.5	0.82	11.1	1.12	10.3	.91	0.37	0.60	2.08	1.08	1.03
7	Acid phosphate 200 lbs. Muriate of potash 25 lbs. Nitrate of soda 100 lbs.	10.2	0.88	20.8	1.48	12.0	1.03	23.2	1.88	16.6	1.32	0.51	1.88	4.16	1.94	2.12
8	Acid phosphate 400 lbs. Nitrate of soda 200 lbs.	6.6	0.70	19.1	1.44	16.3	1.41	14.0	1.30	14.0	1.21	0.53	1.76	4.71	2.68	2.42
9	Acid phosphate 400 lbs. Muriate of potash 25 lbs.	9.9	0.70	26.5	1.96	16.6	1.57	14.8	1.38	17.0	1.40	0.46	2.35	5.44	2.36	2.65

TABLE 6—(Cont.)—*Fertilizer treatments and yields per acre of the several crops grown in a five-year rotation of corn-cotton, soybeans, wheat, and clover and grass (2 years) on a brownish-red soil. Experiments on the farm of the Middle Tennessee State Normal, Murfreesboro.*

Series	Fertilizer	Corn										Seed cotton					Soybean hay				
		1920		1921		1922		1923		4-yr. average		1920	1921	1922	1923	4-year average	1920	1921	1922	1923	4-year average
		Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover										
		Bu.	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons	Bu.	Tons	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Tons	Tons	Tons	Tons	Tons
1	Acid phosphate 200 lbs.	65.8	1.60	43.5	1.34	39.7	1.14	36.1	0.91	46.3	1.25	1591	2180	978	576	1331	1.27	2.69	2.56	2.83	2.34
2	Acid phosphate 200 lbs. Muriate of potash 25 lbs.	63.7	1.60	39.8	1.25	38.6	1.14	37.2	1.16	44.8	1.29	1615	2335	960	648	1390	1.23	2.06	2.49	2.74	2.13
3	No fertilizer	49.0	1.33	44.1	1.45	32.5	0.92	30.5	1.24	39.0	1.24	1255	1828	980	559	1156	1.09	2.12	1.67	1.65	1.63
4	Nitrate of soda 100 lbs.	63.4	1.75	46.3	1.62	34.4	1.01	32.9	1.23	44.3	1.40	1064	2070	907	552	1148	.99	2.26	1.67	1.34	1.57
5	Acid phosphate 200 lbs. Nitrate of soda 100 lbs.	56.9	1.40	54.3	1.62	37.7	0.97	37.5	1.08	46.6	1.27	1309	2530	1273	784	1474	1.03	3.06	2.24	2.23	2.14
6	Muriate of potash 25 lbs. Nitrate of soda 100 lbs.	40.3	1.25	60.0	1.30	31.9	0.93	29.3	1.52	40.4	1.25	1174	2080	943	960	1289	0.97	2.04	1.35	1.46	1.46
7	Acid phosphate 200 lbs. Muriate of potash 25 lbs. Nitrate of soda 100 lbs.	53.4	1.55	58.5	1.70	34.9	1.04	34.1	1.59	45.2	1.47	1387	1880	1122	1056	1361	1.25	2.70	1.79	2.22	1.96
8	Acid phosphate 400 lbs. Nitrate of soda 200 lbs.	38.8	1.40	50.5	1.74	39.8	1.09	37.4	1.47	41.6	1.43	1358	2250	1281	880	1442	.97	3.02	2.08	2.51	2.15
9	Acid phosphate 400 lbs. Muriate of potash 25 lbs. Nitrate of soda 200 lbs.	43.1	1.60	50.0	1.40	35.1	1.05	37.0	1.50	41.3	1.39	1480	2430	1543	1208	1665	1.01	3.18	1.98	2.76	2.23

DISCUSSION OF RESULTS

The response to phosphate was evident not only for all crops but also in every individual plot where a comparison with an unphosphated plot was possible. It gave the most profitable returns for cotton and the least for corn.

WHEAT PLOTS

No phosphate — Phosphate

For each crop there are four plots which received potash and four to which none was applied, but which were otherwise similarly fertilized. Analysis of the data leaves doubt as to the value of an application of potash for any crop. Both the corn and soybean crops yielded, on the average, a little less with than without potash. The clover and grass and the wheat averaged a little more with the potash than without, but in the case of the clover and grass two potash plots showed gains and two showed losses. It is evident, therefore, that the soil exhibited no special need of this element.

The good yields obtained on the unfertilized plots indicate a fair natural supply of nitrogen. The response to nitrating was not positive for any crop, and the use of nitrate on this soil, which is above the average in productivity, is evidently hazardous. On the other hand, a poor soil of the same origin might be nitrated profitably, especially for cotton and truck crops.

LIMING EXPERIMENTS ON RED LAND

The effect of lime was tested by liming lengthwise one-half of each of the five ranges used in the five-year rotation experiments, so as to have a limed and an unlimed half to each plot. In addition an adjoining range was used in the alfalfa experiments reported in Table 5.

The results as summarized in Table 7 show a slight gain from liming for all crops of the five-year rotation, the gain being most pronounced in the case of the clover and grass. Alfalfa, however, was practically a failure without lime, and is an example of a crop with an extra-high lime requirement.

Liming experiments were made on red land on another part of the farm. Several limed and unlimed plots were seeded to red clover and a like set to alfalfa in the fall of 1919. The hay crops harvested in 1920 were found to average as follows:

	Red Clover	Alfalfa
Limed	2967 pounds	3300 pounds
Unlimed	3028 pounds	1960 pounds

In this series the red clover did not respond to liming, but the response of alfalfa was very marked.

FERTILIZER AND LIMING EXPERIMENTS ON GRAY LAND

The gray land available for experiments was somewhat low and poorly drained. Unfortunately it proved to be a little uneven in productivity, so that the true value of the results obtained is in doubt. The data as they stand in Table 8 indicate the following:

1. That there was no evident response to the application of acid phosphate in the case of corn or soybeans; there was mild response from wheat, and only a slight response from clover and grass.

2. That there was a small but consistent response to potash.

3. That both wheat and hay crops were appreciably increased by nitrating.

4. That the response to liming was sufficiently marked to be of practical importance.

GENERAL CONCLUSIONS

Rutherford county soils for the most part belong to a group which is naturally fertile, but somewhat deficient in phosphoric acid, and not well supplied with lime. Under good methods of livestock farming it is easily possible to maintain a high degree of soil productivity without the aid of commercial fertilizers other than the moderate use of a plain phosphate, such as acid phosphate. Under one-sided cropping in corn and cotton, with little return of manure, a deficiency not only of phosphoric acid but also of nitrogen and lime becomes increasingly evident. The evidence indicates strongly that potash, if required at all, is of subordinate importance and even of doubtful value in farm practice.

Under the conditions outlined, the kind and quantity of fertilizer and the need of liming will be influenced both by the kind of crop and by the previous treatment of the soil. If a soil has been well cared for and produces good crops of red clover, liming is not indicated as profitable or necessary, although it might be necessary for a high-lime-requirement crop, such as alfalfa. On the other hand, lands that are worn and eroded usually need liming in order to produce a satisfactory crop of red clover. The Station's usual recommendation in such a case is two tons of ground limestone per acre once in five or six years; but lighter and more frequent applications, say a ton every four years, would probably be ample on these soils.

High-priced crops can evidently be fertilized much more heavily than low-priced. This is especially true of Burley tobacco, which makes a high-grade leaf only under conditions of high yield. Present prices of cotton justify the liberal use of fertilizers for this crop. The same may be said of garden or truck crops in general. On the contrary, corn, which is not only low-priced but also not especially responsive to fertilizers, should not receive much fertilizer. The uncertainty of the small grains, both as to price and yield, makes the use of fertilizers other than a light application of, say, 100 pounds per acre of acid phosphate, of doubtful profit, unless clover and grass follow, in which case a rather liberal application of phosphate is advisable, say 200 or 300 pounds of acid phosphate per acre. In this way the small grain, the clover and grass, and the corn or other crop following are all helped.

FERTILIZER FORMULAS AND RECOMMENDATIONS

WHEAT FOLLOWED BY CLOVER AND GRASS

For wheat or other small grain crop to be followed by clover and grass, apply 200 to 300 pounds per acre of high-grade (16 per cent) acid phosphate. The simplest method of application is by means of a grain drill having a fertilizer attachment, with which seeding and fertilizing are done at one operation. Acid phosphate and fertilizer mixtures in general may, however, be scattered broadcast by hand either before or after plowing, much as farmyard manure is applied, and so get well mixed with the soil.

Top-dressing the wheat with manure in the winter or early spring is very favorable both to the wheat and to the getting of a stand of clover and grass.

SOYBEANS AND COWPEAS

For soybeans, cowpeas, and similar legumes, 100 to 200 pounds of acid phosphate per acre may be used to good advantage. Make the application in the row or broadcast, according to the method of seeding.

CORN AND SIMILAR CROPS

Crops such as corn, sorghum, and millet can not be heavily fertilized with profit. They should follow a soil-improving crop which has been well fertilized, such as clover and grass. However, in experiments conducted for several years on poor soils of the Highland Rim, where the average yield without fertilizer was only 15½ bushels per acre, the yield was found to be increased materially by 225 pounds per acre of the following mixture:

1200 pounds of high-grade acid phosphate
100 pounds of muriate of potash
720 pounds of cottonseed meal

This mixture analyzes approximately as follows:

Available phosphoric acid	10.0 per cent
Ammonia	2.8 per cent
Potash	3.0 per cent

The application can well be made in the row at planting time.

TOBACCO

Tobacco, especially Burley, requires a fertile soil, and if possible sod land should be selected. Based in part on experiments made elsewhere in the State, a good formula is as follows:

300 pounds of acid phosphate
25 pounds of muriate of potash
40 pounds of nitrate of soda
200 pounds of cottonseed meal

This mixture analyzes approximately as follows:

Available phosphoric acid	6¾ per cent
Ammonia	4 per cent
Potash	2¾ per cent

Five or six hundred pounds of this mixture per acre is a reasonable quantity. Instead of the 200 pounds of cottonseed meal and 40 pounds of nitrate, either 300 pounds of cottonseed meal, or 90 pounds of ammonium sulphate, or 120 pounds of nitrate of soda may be used; but the larger quantities of either nitrate or sulphate tend to lower the quality of the leaf.

Heavy applications may be made, either all broadcast before ridging, or part in the row and the balance broadcast. Light applications are most effective when applied in the row.

TRUCK CROPS

A good formula for tomatoes, Irish potatoes, and other truck crops is as follows:

300 pounds of acid phosphate
50 pounds of muriate of potash
400 pounds of cottonseed meal

This mixture analyzes approximately as follows:

Available phosphoric acid	7¾ per cent
Ammonia	4¼ per cent
Potash	4 per cent

Instead of 400 pounds of cottonseed meal, either 160 pounds of nitrate of soda, or 125 pounds of ammonium nitrate may be used; but the nitrate is best applied separately as a top-dressing according to the usual rules.

TABLE 7—*Effect of liming in experiments with various crops on brownish-red soil—rate of liming, two tons of ground limestone per acre. Experiments on the farm of the Middle Tennessee State Normal, Murfreesboro.*

(Four-year period)

Crop	Year of harvest and yield per acre								Average annual yield		Average annual gain from liming
	1920		1921		1922		1923				
	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	
Cotton	1348 lbs.	1288 lbs.	2081 lbs.	2125 lbs.	1178 lbs.	1092 lbs.	812 lbs.	801 lbs.	1355 lbs.	1327 lbs.	28 lbs.
Corn	53.8 bu.	46.2 bu.	47.5 bu.	47.7 bu.	33.1 bu.	37.3 bu.	34.0 bu.	33.6 bu.	42.1 bu.	41.2 bu.	0.9 bu.
Soybean hay	2300 lbs.	2040 lbs.	5080 lbs.	4840 lbs.	3620 lbs.	3940 lbs.	4200 lbs.	4240 lbs.	3800 lbs.	3765 lbs.	35 lbs.
Wheat	8.9 bu.	9.2 bu.	19.7 bu.	17.1 bu.	12.7 bu.	11.7 bu.	11.4 bu.	14.1 bu.	13.2 bu.	13.0 bu.	0.2 bu.
Clover and grass hay	611 lbs.	912 lbs.	1835 lbs.	1889 lbs.	7107 lbs.	6305 lbs.	4240 lbs.	3120 lbs.	3448 lbs.	3057 lbs.	391 lbs.
Alfalfa	....	....	5140 lbs.	2160 lbs.	8400 lbs.	1700 lbs.	3520 lbs.	1500 lbs.	5687 lbs.	1787 lbs.	3900 lbs.

freesboro—gray soil.

Series	Fertilizer	CROP									
		Soybean hay*		Wheat		Clover and grass hay*		Corn			
		Limed	Unlimed	Limed	Unlimed	Limed	Unlimed	Limed		Unlimed	
		Tons	Tons	Bushels	Bushels	Tons	Tons	Bushels	Tons	Bushels	Tons
1	Acid phosphate 200 lbs.	2.06	1.98	11.7	13.7	1.75	1.75	24.4	.80	29.6	.99
2	Acid phosphate 200 lbs. Muriate of potash 25 lbs.	2.17	1.98	10.7	11.9	1.78	1.92	28.9	.89	33.1	1.06
3	No fertilizer (avg. 3 check plots)	2.50	1.80	11.0	8.1	2.04	1.39	29.5	1.10	22.9	.76
4	Nitrate of soda* 100 lbs.	2.17	1.82	16.0	11.3	2.91	2.07	33.0	1.31	28.8	.93
5	Acid phosphate 200 lbs. Nitrate of soda* 100 lbs.	2.11	2.10	18.7	17.9	2.66	2.02	32.2	1.05	31.2	.93
6	Muriate of potash 25 lbs. Nitrate of soda* 100 lbs.	2.33	1.83	15.8	14.5	2.62	2.07	34.2	1.04	31.8	1.05
7	Acid phosphate 200 lbs. Muriate of potash 25 lbs. Nitrate of soda* 100 lbs.	2.53	2.40	22.1	21.1	2.86	2.27	34.4	1.07	29.6	1.00
8	Acid phosphate 400 lbs. Nitrate of soda* 200 lbs.	2.39	1.26	25.4	20.6	2.89	2.17	34.2	1.04	31.1	.91
9	Acid phosphate 400 lbs. Muriate of potash 50 lbs. Nitrate of soda* 200 lbs.	2.73	1.65	22.1	21.1	2.96	2.16	32.3	1.22	3.45	1.09
	Average	2.33	1.87	17.1	15.6	2.50	1.98	31.5	1.06	30.3	.97